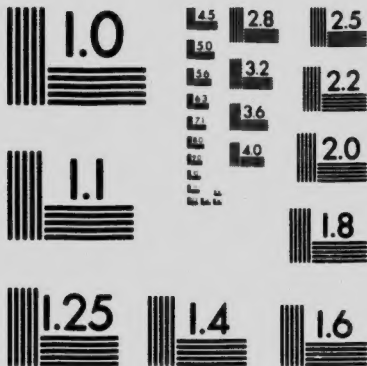




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STANDARD REFERENCE MATERIAL 1010a
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THE METRIC SYSTEM

OF

WEIGHTS AND MEASURES

BY

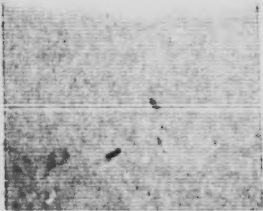
PROFESSOR J. C. McLENNAN



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ADDENDUM

TO

PROF. J. C. McLENNAN'S EVIDENCE.

ON THE

METRIC SYSTEM OF WEIGHTS AND MEASURES

BEFORE THE SELECT STANDING COMMITTEE ON AGRICULTURE AND
COLONIZATION, OF THE HOUSE OF COMMONS OF CANADA, MARCH
29TH, 1904,—SUPPLIED BY HIMSELF.

THE METRIC SYSTEM OF WEIGHTS AND MEASURES.

HISTORICAL DEVELOPMENT.

The moment that primeval man emerged from a state of almost animal barbarism, the natural tendency to acquire property made itself manifest. All possessions of value must necessarily bear some relation to each other, and such relation, the base of any system of barter, can only be established by some means of measurement. The simplest form of measurement, of course, is mere enumeration; but the ability to count alone could not long satisfy the needs of the dawning intelligence of men. In consequence our earliest ancestors found it necessary to adopt some standard and naturally turned to objects more or less constant either in size, weight or some other physical property. The lack of intimate association between the early communities necessarily gave rise to diverse standards of measurement, resulting in a confusion which was further increased by a natural tendency to adopt as standards personal measurement, such as the length of the foot and the arm, the first joint of the thumb, &c. Owing to the different stature of men in different localities these standards were very inexact and their elasticity greatly favoured fraud on the part of unscrupulous dealers. As an example of the origin of these diverse measurements, which were in no way related to each other, and which were in every case excessively local in their application, may be cited the origin of the inch from the length of the first joint of the thumb and that of the yard from the length of the king's arm. More indefinite still were such terms as 'furlong,' meaning a furrow long, and 'perch,' derived from the Latin *pertingo*, to stretch. Standards of weight were fully as indefinite as those of linear measurement, as may be seen from the fact that our familiar 'pound' owes its origin to nothing more definite than the Latin *pondus*, a weight.

Unsatisfactory as were these crude attempts at measurement, they nevertheless answered the purpose of isolated communities, but soon the exigencies of trade between the different centres of civilization brought a new factor into the field and emphasized the confusion already existing. Furthermore, when national growth manifested itself and organized government appeared, the collection of revenue forced the adoption of something approaching a fixed standard and necessitated a definite relation between the different units of the systems of weights and measures. It is quite natural that buyer and seller should have different ideas of the length of a thumb joint, and we find that this difference of opinion was fully shared by the revenue officers and the importers of foreign goods. It is, however, to the government control of revenue that we owe the nationalizing and eventually the legalization of a system of standards.

Taking Great Britain as an example, we find that the attempts to reduce measurement to a standard proved an undertaking of great difficulty and that five centuries elapsed after the Norman conquest before anything like uniformity was attained. Even to-day many of the early units are clung to with a remarkable persistency. For example, the term 'stone' is still largely used in Great Britain and the expression 'baker's dozen' is frequently heard even in Canada.

It is worthy of note that no attempt has ever been made in the British empire to establish a relationship between the units of mass, length and volume. A possible exception to this statement may be found in the fact that a gallon of cold water is officially recognized to weigh ten pounds.

It is at once manifest that the legalization of the standards in each country tended only to the lessening of the confusion in that particular realm. The standards adopted by the different states were in no way related to each other, and consequently as international commerce and scientific investigation increased the need of a universal system of weights and measures became more and more apparent.

About the beginning of the eighteenth century the creation of a universal system began to be mooted by the leading scientists in Europe. Among the most active of these was James Watt, the inventor of the steam engine, who suggested the universal adoption of the Paris pound as the standard of mass and the length of the seconds pendulum at Paris as the standard of length.

He also proposed that all subdivisions and multiples of these standards should be decimally connected. Watt's proposal for a decimal system of weights and measures was not new, having been made by Sir James Stuart nearly a hundred years earlier, while the suggestion to derive the standard of length from the pendulum had been made by the French scientist, Picard, many years before.

In France especially the want of uniformity in the weights and measures of the different provinces had for a long period been exceedingly embarrassing and troublesome in the transaction of affairs. Various attempts had been made during the 16th and 17th centuries to establish a uniform system of weights and measures for that country, but it was not until near the close of the 18th century that the question assumed such importance as to warrant legislative action on the part of the National Assembly. In 1789 the assemblage of the States-General in Paris brought to a focus the long-felt discontent at the numberless variations in use in various parts of France and in the following year the Academy of Sciences was instructed to devise a system of weights and measures which would be suitable for all nations. This the Academy undertook to do, and the Royal Society of London was asked to take part in the movement, but declined the invitation, and England accordingly lost any share of the credit for formulating the new system.

The scheme of the Academy of Sciences, known as the Metric System of Weights and Measures, was laid before the National Convention in 1793, and received its endorsement. In this scheme all previous units were abandoned, and, in order to give it

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an extremely international character, the standard of length was based upon the length of a quadrant of the earth's meridian. The ten millionth part of this length was called *the metre*, and on this unit, together with the maximum density of water, the whole system of weights and measures was built up, all subdivisions and multiples of the standard unit, according to Watt's proposal, being decimally connected.

In order to carry out the scheme of the Academy, Delambre and Mechain, two able mathematicians and distinguished scientists, undertook to measure an arc on the earth's surface, from which the total length of the quadrant of a meridian could be calculated. The arc selected extended from Dunkirk in the north of France to Barcelona on the east coast of Spain. Their task occupied about seven years, and at its conclusion their measurements and calculations were submitted to a 'Commission of Weights and Measures,' composed of 22 members chosen from the various countries of Europe, who, after carefully revising all the computations, arrived at a determination of the length of the metre, and proceeded at once to the practical realization of this standard of length. A bar of platinum one metre in length at the temperature of melting ice was constructed with the greatest care by Lenoir under the direction of Borda, and this bar, known as the *Mètre des Archives*, is still preserved in the *Palais des Archives*, and serves as the first practical standard of length in the metric system.

In the scheme presented by the Academy of Sciences, the theoretical unit of mass, or weight as it is popularly spoken of, was called the gramme, and was defined to be the mass of distilled water, which, at its maximum density, would exactly fill a cube with an edge one hundredth of a metre in length. This theoretical unit was small, and a larger one, the kilogramme, was adopted for practical purposes. The kilogramme is equal to 1,000 grammes, and is the mass of distilled water which, at the temperature of 4°C, under an atmospheric pressure equal to that represented by a column of mercury 760 millimetres high at 0°C, at sea level, and at latitude 45 degrees, would exactly fill a cube with an edge equal to one-tenth of a metre.

A cylinder of platinum was constructed by Borda, with the greatest possible precision, so as to have a mass equal to that of the kilogramme just defined, and was deposited along with the metre in the *Palais des Archives* at Paris. This standard mass, which is known as the *Kilogramme des Archives*, and the standard metre referred to above, form the basis of the scheme elaborated by the Academy of Sciences, and they are the two practical units to which all the weights and measures of the metric system are referred.

Such is briefly the history of the origin of a system of weights and measures which, in spite of opposition, has now been adopted by a large majority of the nations of the world, who recognize its value and appreciate its extreme simplicity.

The metric system of weights and measures was made compulsory in France in 1802, but as many opposed its adoption, it was subsequently decreed by the National Convention in 1812 that the old measures, though metrically altered, should still be used. This system of compromise went on until 1837, when a law was passed which prescribed that from January 1, 1840, none but the weights and measures of the metric system should be employed, and that the use of unauthorized measures should be punishable. Since the passing of this law the metric system, and that alone, has been the legal system in force in France.

The agitation in favour of the metric system gradually extended throughout Europe, and soon after the constitution of the German empire it was adopted in that country. An Act passed in August, 1868, made it optional from January 1, 1872, and since then the metric system alone has been legalized in Germany. In 1873 its use was made obligatory in Austria, and somewhat later in Italy. The movement has extended to America, to Africa and to Asia, and at the present time the metric system is the one official and legal system of weights and measures in force in forty-three of the countries of the world. In the United States, in Great Britain and Ireland, and

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also in a number of the British dependencies, including Canada, this system has been legalized, but not as yet made compulsory.

In 1867 the International Geodetic Conference, which assembled in Berlin, expressed the view that in the interest of science in general and of geodesy in particular, a unique system of weights and measures, with decimal subdivisions, should be adopted in Europe, that the system selected should be the metric system, that a new metre of length equal to that of the *Mètre des Archives* of France should be constructed as an international standard, that a number of additional copies for distribution as standards to different countries should be prepared, and that for this purpose an International Bureau of Weights and Measures should be established.

In 1875 an agreement, known as the International Metric Convention, was entered into by eighteen contracting states—since increased by successive adhesions to twenty-two—by which the proposals of the geodetic conference were adopted. In conformity with this agreement an international bureau of weights and measures was established at Sèvres, on the banks of the Seine near Paris, and is now maintained at the common expense of the contracting states.

The first work undertaken by this bureau was the preparation of a new international standard metre and a new international standard kilogramme. In establishing these new international prototypes the old standards of the Archives of France were taken as a basis. Platinum-iridium alloy was used in their construction, and they were standardized by the most approved methods and by means of the most perfect instruments which science and the art of construction have placed at our disposal. They are now kept in a vault underground at Sèvres under lock and key, and are inspected only once in ten years, and even then they are not handled more than is absolutely necessary.

Copies of the 'International Metre' and the 'International Kilogramme' have been distributed as standards to those governments which have signed the convention, and others are being constantly prepared by the bureau for distribution to public institutions, scientific societies, observatories and laboratories, as well as to scientists and to the manufacturers of instruments of precision. All these copies are constructed and verified with the greatest precision, and can replace the international standards in case the latter by any mischance should be lost.

The probability of the loss or destruction of all the standards is very remote, but the possibility of alteration through molecular changes in the prototypes is not to be disregarded. Consequently it was thought advisable to measure the international metre in terms of some physical constant of an absolutely unchangeable nature. The wave length of the light emitted from well defined lines in a spectrum is absolutely constant and depends on the vibrations of the ever-present and unalterable ether. The length of such waves was, therefore, regarded as particularly suitable for the purpose of recording the length of the international metre in terms of a factor entirely removed from the possibility of change with the lapse of time.

In 1892 Michelson was invited to carry out this work at the International Bureau and an extended series of the most careful measurements was conducted by this distinguished scientist with the red, green and blue lines of cadmium as the source of light, and the length of the metre was found to be 1,553,163.5 wave lengths of the red light, 1,966,249.7 wave lengths of the green light and 2,083,372.1 wave lengths of the blue light of the cadmium spectrum.

Advances in methods of measurement and refinement in the construction of instruments of precision have shown us that the international metre differs slightly from one-ten-millionth part of a quadrant of the earth's meridian, and that the mass of the international kilogramme is not exactly equal to the mass of a cubic decimetre of water at its maximum density, but this fact, while it robs us of the sentiment connected with the origin of these prototypes, does not detract in the least from their value as the basis of the metric system.

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UNITS OF LENGTH AND MASS IN THE METRIC SYSTEM.

The fundamental units of length and mass in the metric system of weights and measures are the *metre* and the *gramme*, and these, with their multiples and sub-multiples, which are decimally connected suffice for the expression of all measurements of length, area, capacity, volume, mass and weight. The multiples of the metre and the gramme are denoted by the prefixes *deca*, *hecto*, *kilo* and *myria*, which are derived from the Greek words *deka*, *hekaton*, *chilioi* and *myrioi*, signifying 10, 100, 1,000 and 10,000 respectively, and their submultiples by the prefixes *deci*, *centi* and *milli*, which are derived from the Latin words *decem*, ten; *centum*, a hundred; and *mille*, a thousand.

The different units of the metric system are presented in the following tables and accompanying them for comparative purposes are the weights and measures commonly used in Canada at the present time :—

THE NAMES OF THE METRE UNITS.

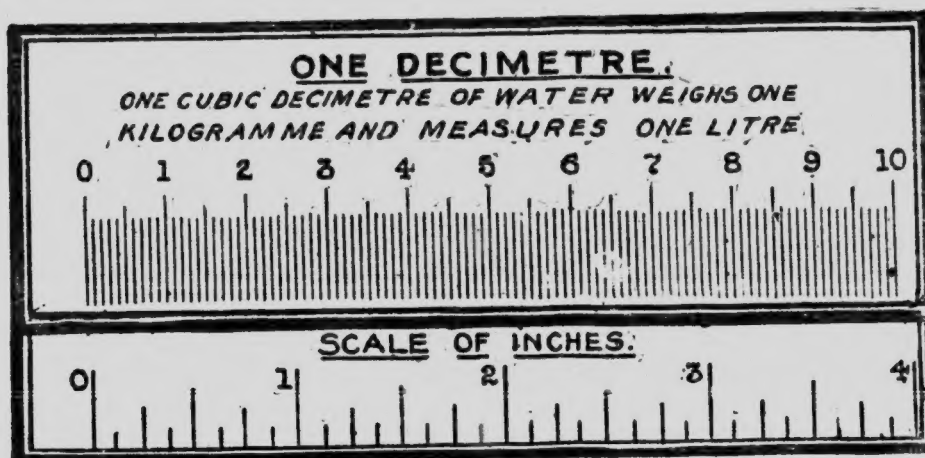
Prefixes.				Units Length.	Mass Weight.	Capacity.
Sub-multiples	Milli.	=	$\frac{1}{1000}$	Metre.	Gramme.	Litre.
	Centi	=	$\frac{1}{100}$			
	Deci	=	$\frac{1}{10}$			
	Deka.	=	10			
Multiples	Hecto.	=	100			
	Kilo.	=	1,000			
	Myria.	=	10,000			

THE METRE.

The length of the metre is equal to.....
 $\left\{ \begin{array}{l} 39.370113 \text{ inches.} \\ 3.280843 \text{ feet.} \\ 1.0936143 \text{ yards.} \end{array} \right.$

Or about 1-10th longer than the British yard.

The following diagram represents a decimetre graduated in centimetres and millimetres, and beneath it for comparison is a scale of inches.



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LINEAR MEASURE.

<i>Metric</i>			<i>British.</i>
10 millimetres	=	1 centimetre	12 lines = 1 inch
10 centimetres	=	1 decimetre	4 inches = 1 hand
10 decimetres	=	1 metre	7·92 inches = 1 surveyor's link
10 metres	=	1 decametre	12 " = 1 engineer's link
10 decametres	=	1 hectometre	12 " = 1 foot
10 hectometres	=	1 kilometre	3 feet = 1 yard
10 kilometres	=	1 myriametre	6 " = 1 fathom
			5½ yards = 1 rod
			100 links = 1 chain (66 ft.)
			(Surveyor's) (Surveyor's)
			100 links = 1 chain (100 ft.)
			(Engineer's) (Engineer's)
			40 rods = 1 furlong
			8 furlongs = 1 statute mile
			1·158 statute miles = 1 nautical mile
			3 statute miles = 1 league

Measurements now expressed in yards will, under the Metric System, be expressed in metres; those expressed in feet will be decimetres, and centimetres will take the place of fractions of an inch. For all practical purposes of comparison 1 yard may be taken as 0·9 metres, 1 foot as 3 decimetres, 1 inch as 25 millimetres, and one kilometre as five-eighths of a mile.

SURFACE MEASURES.

METRIC.

The Surface Units are the Linear
Units squared
For Land Measure the unit of measure-
ment is the *Arc*, which is equal to
100 square metres
100 centiares = 1 are
100 ares = 1 hectare.

BRITISH.

144 square inches = 1 square foot
9 square feet = 1 square yard
30½ square rods = 1 square rod
40 square rods = 1 rood
4 roods = 1 acre
640 acres = 1 square mile

Surveyor's Measure.

625 square links = 10 square rods
16 square rods = 15 square chains (surveyor's)
10 square chains = 1 acre
640 acres = 1 square mile
36 square miles = 1 township

In surface measurements the square metre and the square decimetre will replace the square yard and the square foot. For land measures the practical unit is the *hectare*, which is approximately equal to 2·5 acres.

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VOLUME AND CAPACITY MEASURES.

METRIC.	BRITISH.
Metric cubic units are the linear units cubed, e.g., cubic metre.	Volume Measure.
The practical unit of capacity is the Litre which is equal to one decimetre.	1728 cubic inches = 1 cubic foot
10 millilitres = 1 centilitre	27 cubic feet = 1 cubic yard
10 centilitres = 1 decilitre	42 cubic feet = 1 ton (of shipping)
10 decilitres = 1 litre	128 cubic feet = 1 cord (firewood)
10 litres = 1 decalitre	Capacity Measure.
10 decalitres = 1 hectolitre	4 gills = 1 pint
10 hectolitres = 1 kilolitre	2 pints = 1 quart
The practical unit of volume is the Stere which is equal to 1 cubic metre.	4 quarts = 1 gallon
10 decistères = 1 stère	2 gallons = 1 peck
10 stères = 1 decastère	4 pecks = 1 bushel
	8 bushels = 1 quarter
	5 quarters = 1 load
	Apothecaries' Measure.
	20 minims = 1 fluid scruple
	3 fluid scruples = 1 fluid dram
	8 fluid drams = 1 fluid ounce*
	20 fluid ounces = 1 pint
	2 pints = 1 quart
	4 quarts = 1 gallon
	*(1 fluid ounce of distilled water at 60°F weighs 1 ounce avordupois).

Under the Metric System measurements now expressed in cubic yards will be made in cubic metres. The bushel, peck, gallon, quart and pint will disappear, and measurements made in gallons and quarts will be made in litres. The stère will replace the cord in the measurement of firewood, and the cubic yard in the measurement of stone, gravel or sand. For practical purposes the cubic foot may be taken as equal to 28 cubic decimetres and the litre is approximately equal to the quart.

TABLES OF WEIGHT.

METRIC.	BRITISH.
10 milligrammes = 1 centigramme	(1) Apothecaries'
10 centigrammes = 1 decigramme	20 grains = 1 scruple
10 decigrammes = 1 gramme	3 scruples = 1 dram
10 grammes = 1 decagramme	8 drams = 1 ounce
10 decagrammes = 1 hectogramme	12 ounces = 1 pound
10 hectogrammes = 1 kilogramme	(2) Troy.
10 kilogrammes = 1 myriagramme	24 grains = 1 pennyweight
10 myriagrammes = 1 quintal	20 pennyweights = 1 ounce
10 quintals = 1 ton (metric)	12 ounces = 1 pound
	(3) Avordupois.
	16 drams = 1 ounce
	16 ounces = 1 pound
	25 pounds = 1 quarter
	4 quarters = 1 hundredweight*
	20 hundredweight = 1 ton
	* The long hundredweight = 112 pounds
	and the long ton = 2,240 pounds

Under the Metric System measurements in pounds will be made in kilogrammes and grammes and decimals of a gramme will be used instead of ounces and grains.

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The metric ton, which differs but slightly from the ton now in use, will replace the latter. The kilogramme is approximately equal to 2·2 pounds and the pound is, therefore, but slightly different from one-half of a kilogramme. For practical purposes the ounce, avordupois, may be taken as 28 grammes and the apothecaries' ounce as 31 grammes.

CUSTOMARY WEIGHTS AND MEASURES HAVING MORE THAN ONE VALUE.

Ling = 7·92 inches (Gunthers' or surveyors') and 12 inches (engineers').
 Chain = 66 feet (surveyors') and 100 feet (engineers').
 Mile = 5,280 feet (land measure) and 6,080 feet (nautical measure).
 Dram = 27·344 grains (Avoirdupois) and 60 grains (Apothecaries').
 Ounce = 437·5 grains (Avoirdupois) and 480 grains (Troy and Apothecaries').
 Pound = 5,760 grains (Apothecaries' and Troy) and 7,000 grains (Avoirdupois).
 Ton = 2,000 pounds (short ton) and 2,240 pounds (long ton).

APPROXIMATE BRITISH EQUIVALENTS.

<i>Metric Measures.</i>		<i>Equivalents.</i>	<i>Approximate equivalents.</i> (In measures at present in use.)
1 kilometre	=	0·62137 miles	$\frac{5}{8}$ ths of a mile.
2 kilometres	=	1·24274 miles	a mile and a quarter.
1 metre	=	39·37 inches	1 yard.
1 hectare	=	2·4711 acres	2½ acres.
$\frac{1}{2}$ hectare	=	1·2356 acres	1 acre.
1 litre	=	1·76 pints	1 quart.
1 kilogram	=	2·2046 pounds	2 pounds.
$\frac{1}{2}$ kilogram	=	1·1023 pounds	1 pound.
1 ton	=	2204·6 pounds	1 ton.
1 stero	=	1·307954 cubic yards	1 cubic yard.

From this table it will be seen that in the transition stage it will be quite practicable to apply a few of the names of the weights and measures now in use to some of the more common of the new metric measures.

EQUIVALENTS OF METRIC WEIGHTS AND MEASURES IN TERMS OF IMPERIAL WEIGHTS AND MEASURES FOR USE IN TRADE.

Legalized by the Queen's Most Excellent Majesty in Council, May 19, 1898.

Metric to Imperial.

LINEAR MEASURE.

1 Millimetre	=	0·000937 Inch.
1 Centimetre	=	0·3937 "
1 Decimetre	=	3·937 "
<i>Metre (m.)</i>	=	39·370113 "
		3·280843 Feet.
		1·0936143 Yards.
1 Decametre	=	10·936 Yards.
1 Hectometre	=	109·36 "
1 Kilometre	=	0·62137 Mile.

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SQUARE MEASURE.

1 Square Centimetre	=	0.15500 Sq. Inch.
1 Sq. Decimetre	=	15.500 "
1 Sq. Metre	=	10.7639 Sq. Feet.
1 Are	=	1.1960 Sq. Yards.
1 Hectare	=	119.60 Sq. Yards.
	=	2.4711 Acres.

CUBIC MEASURE.

1 Cubic Centimetre	=	0.0610 Cubic Inch.
1 Cubic Decimetre	=	61.024 "
1 Cubic Metre	=	35.3148 Cubic Feet.
	=	1.307954 Cubic Yards.

MEASURE OF CAPACITY.

1 Centilitre	=	0.070 Gill.
1 Decilitre	=	0.176 Pint.
1 Litre	=	1.75980 Pints.
1 Dekalitre	=	2.200 Gallons.
1 Hectolitre	=	2.75 Bushels.

MEASURES OF WEIGHT.

		<i>Avoirdupois.</i>
1 Milligramme	=	0.015 Grains.
1 Centigramme	=	0.154 "
1 Decigramme	=	1.543 Grains.
1 Gramme	=	15.432 "
1 Dekagramme	=	5.644 Drains.
1 Hectogramme	=	3.527 Ozs.
1 Kilogramme	=	2.2046223 Lb. or 15432.3504 Grains.
1 Myriagramme	=	22.046 Lbs.
1 Quintal	=	1.968 Cwt.
1 Tonne	=	0.9842 Ton.
		<i>Troy.</i>
1 Gramme	=	0.03215 Oz. Troy.
	=	15.432 Grains.
		<i>Apothecaries.</i>
1 Gramme	=	0.2572 Dram.
	=	0.7716 Scruples.
	=	15.432 Grains.

EQUIVALENTS OF IMPERIAL AND METRIC WEIGHTS AND MEASURES.

Imperial to Metrical.

LINEAR MEASURE.

1 Inch	=	25.400 Millimetres.
1 Foot	=	0.30480 Metres.
1 Yard	=	0.914399 Metres.
1 Fathom	=	1.8288 Metres.
1 Pole	=	5.0292 "
1 Chain	=	20.1168 "
1 Furlong	=	201.168 "
1 Mile	=	1.6093 Kilometres.

§THE IMPERIAL YARD.

It was enacted by the British Parliament (18 & 19 Victoria, c. 72, July 30, 1855) 'that the straight line or distance between the centres of the transverse lines in the gold plugs in the bronze bar deposited in the office of the Exchequer shall be the genuine standard yard' at 62° Fahrenheit, and if lost it shall be replaced by its copies.'

The authorized copies here referred to are those which are preserved at the Royal Mint, the Royal Society of London, the Royal Observatory at Greenwich, and the New Palace at Westminster.

*By 42 Victoria, c. 1684, the Dominion Standards of weight and measure are the yard and the pound as represented by a certain bronze bar and a platinum-iridium weight (copies of the British Standards) deposited at the Department of Inland Revenue in the custody of the Minister of Inland Revenue.

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SQUARE MEASURES.

1 Square Inch	=	6.4516 Sq. Centimetres.
1 Sq. Foot	=	9.2903 Sq. Decimetres.
1 Sq. Yard	=	0.836126 Sq. Metre.
1 Perch	=	25.293 Sq. Metres.
1 Rood	=	10.117 Ares.
1 Acre	=	0.40468 Hectare.
1 Sq. Mile	=	259.00 Hectares.

CUBIC MEASURE.

1 Cubic Inch	=	16.387 C. Centimetres.
1 Cubic Foot	=	0.028317 Cubic Metre.
1 Cubic Yard	=	0.764553 Cubic Metre.

MEASURES OF CAPACITY.

1 Gill	=	1.42 Decilitres.
1 Pint	=	0.568 Litre.
1 Quart	=	1.136 Litres.
† 1 Gallon	=	4.5459631 Litres.
1 Peck	=	9.092 Litres.
1 Bushel	=	3.637 Dekalitres.
1 Quarter	=	2.900 Hectolitres.

APOTHECARIES' MEASURES.

1 Minim	=	0.059 Millimetre.
1 Fluid Scruple	=	1.184 Millimetres.
1 Fluid Dram	=	3.552 "
1 Fluid Ounce	=	2.84123 Centilitres.
1 Pint	=	0.568 Litre.
1 Gallon	=	4.5459631 Litres.

AVOIRDUPOIS WEIGHT.

1 Grain	=	0.0648 Gramme.
1 Dram	=	1.772 Granimes.
1 Oz.	=	28.350 "
† 1 Pound	=	0.45359243 Kilogrammes.
1 Stone	=	6.350 Kilogrammes.
1 Quarter	=	12.70 "
1 Hundredweight	=	50.80 "
	=	0.5080 Quintals.
1 Ton	{	1.0160 Tonnes or
		1016 Kilograms.

TROY WEIGHT.

1 Grain	=	0.0648 Granimes.
1 Pennyweight	=	1.5552 Grammes.
1 Troy Ounce	=	31.1035 "

APOTHECARIES' WEIGHT.

1 Grain	=	0.0648 Grammes.
1 Scruple	=	1.296 Grammes.
1 Dram	=	3.888 "
1 Oz.	=	31.1035 "

†THE STANDARD POUND.

By the Act cited above, a weight of platinum marked "P. S. 1844, 1 lb.", deposited in the office of the Exchequer, 'shall be the legal and genuine standard measure of weight, and shall be and be denominated the Imperial Standard Pound Avoirdupois, and shall be deemed to be the only standard measure of weight from which all other weights and measures having reference to weight shall be derived, computed and ascertained and one equal seven-thousand part of such pound avoirdupois shall be the grain, and five hundred seven hundred and sixty such grains shall be and be deemed a pound Troy. If at any time hereafter the said Imperial Standard Pound Avoirdupois be lost or in any manner destroyed, defaced, or otherwise injured, the Commissioners of Her Majesty's Treasury may cause the same to be restored by reference to or adoption of any of the copies aforesaid, (1) or such of them as may remain available for that purpose.

†THE IMPERIAL GALLON.

The Imperial Gallon by an Act of the British Parliament, 5e, G. IV, chap. 74, which came into effect on Jan. 1, 1826, was defined to be a measure which contains exactly 10 pound avoirdupois of distilled water weighed in air at the temperature of 62° Fahrenheit with the barometer at 30 inches. The Imperial Gallon was also further defined to contain 277.274 cubic inches.

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REASONS ADVANCED FOR THE ADOPTION OF THE METRIC SYSTEM OF WEIGHTS AND MEASURES IN CANADA AND THE BRITISH EMPIRE GENERALLY.

The advocates of the metric system of weights and measures claim the following advantages for that system :—

1. The metric system is orderly, methodical, clear and extremely simple. In the metric system there is one specific word for each unit, and this word exclusively designates the one thing it is meant to represent. From this one word, to which can be prefixed particles which are the same for all units, every multiple and sub-multiple can be expressed. In this regard the metric has the advantage over the British system, which is complicated, unscientific and anomalous.

2. In the metric system there are no specific trade tables. The same weights and measures are used for all purposes in all trades and industries.

3. The metric system of weights and measures, like our system of notation in arithmetic, which is universally adopted by civilized nations, is a decimal system and involves but the single ratio '10.' For this reason, all reductions in the system are made with the minimum amount of labour, and with no more effort than that involved in the expression of a number. The advantages of the decimal system in the coinage and money of Canada are manifest, and it is claimed that it would be just as convenient to use a similar system in our weights and measures.

4. The adoption of the metric system would materially assist education by facilitating the teaching of arithmetic and setting free a considerable amount of time which would be devoted to more useful subjects than the learning and practising of our complicated and confused tables of weights and measures. Estimates made by committees of inquiry show that the work of at least two-thirds of a year in the life of every child would be saved by the adoption of the metric system of weights and measures.

5. The universal adoption of the metric system of weights and measures by scientists has greatly facilitated the development and spread of scientific knowledge.

6. The international system of electrical units is based upon the metric system. All British and American electrical engineers and workmen must, therefore, work with it, and as long as the British system of units is retained in machine construction, so long will those connected with enterprises involving a knowledge of electricity be put to the inconvenience and unnecessary labour of keeping in mind two systems of standards. It will be seen that the argument has increased force when it is realized that, as new fields of knowledge are opened up and new systems of work evolved, the claims of science will make it imperative to adopt the metric system as a basis.

7. Another claim urged on behalf of the metric system is that it is exceedingly simple in calculation. As each measure of quantity can be written down at once as a decimal or multiple of ten of the standard metrical unit, tedious reductions are avoided and computations are confined to operations involving only the simple rules of arithmetic.

The tiresome process of multiplying or dividing a quantity of tons, hundred-weights, quarters, pounds, &c., by a number, or the still more difficult task of performing a similar operation with an area containing acres, roods, square yards, &c., are well known to every one. The same problems in the metric system are done easily and quickly. The saving in energy consumed by a nation in a year or two in calculations rendered necessary by the use of our present system of weights and measures alone would warrant the universal adoption of the metric system.

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The following calculations, which are typical, illustrate the simplification which will be gained by the adoption of the metric system :—

CALCULATIONS.

1. Reduction of measures to a common denomination.

METRIC SYSTEM.

Reduce to millimetres the following distance :—

8 kilometres
7 hectometres
8 decametres
9 metres
6 decimetres
1 centimetre
2 millimetres

No calculation necessary.

Answer = 8,789,612 millimetres.

BRITISH SYSTEM.

Reduce to inches the following distance :—

5 miles
4 furlongs
7 rods
3 yards
2 feet
9 inches

Multiply by the ratios of the successive units, adding in the number of each unit stated in the problem.

5 miles
x 8

40 furlongs
+ 4 furlongs

44 furlongs
x 40

1760 rods
+ 7 rods

1767 rods
x 5½

8835
883·5

9718·5 yards
+ 3 yards

9721·5 yards
x 3

29164·5 feet
+ 2 feet

29166·5 feet
x 12

349998·0 inches
+ 9

Answer. = 350,007 inches.

APPENDIX No. 2

METRIC SYSTEM.

BRITISH SYSTEM.

2. Find the contents of a tank

3½ metres long.
1.56 metres wide.
82 centimetres deep.

1. Multiply direct—

$$\begin{array}{r} 3.5 \\ .82 \\ \hline 7 \\ 2.80 \\ \hline 2.87 \\ 1.56 \\ \hline 1722 \\ 1435 \\ 287 \\ \hline \end{array}$$

4.4772 cubic metres.

11 feet 4 inches long.
5 feet 2 inches wide.
2 feet 5 inches deep.

1. Reduce to inches and multiply—

11 feet 4 inches = $11 \times 12 + 4 = 136$ in.
5 feet 2 inches = $5 \times 12 + 2 = 62$ in.
2 feet 5 inches = $2 \times 12 + 5 = 29$ in.

$$\begin{array}{r} 136 \\ \times 62 \\ \hline \end{array}$$

$$\begin{array}{r} 272 \\ 816 \\ \hline \end{array}$$

8432 sq. in. in area of base of tank.
 $\times 29$

$$\begin{array}{r} 75888 \\ 16864 \\ \hline \end{array}$$

244528 cubic inches.
1728) 244528 (141 cu. feet.
1728

$$\begin{array}{r} 7172 \\ 6912 \\ \hline \end{array}$$

$$\begin{array}{r} 2608 \\ 1728 \\ \hline \end{array}$$

880 cu. in.
Answer 141 cu. feet 880 cu. inches.

METRIC SYSTEM.

BRITISH SYSTEM.

3. Find the weight of water contained in the above tank.

Capacity = 4.4772 cubic metres
No calculation.
Answer = 4.4772 metric tons.

Capacity = 244,528 cu. inches.
Multiply capacity by weight of a cu. inch of water—
1 cu. foot of water weighs 62.5 pounds.
1 cu. inch weighs 62.5 ÷ 1728 pounds.

$$\begin{array}{r} 1728) 62.5 (.036 \text{ pounds.} \\ 5184 \\ \hline \end{array}$$

$$\begin{array}{r} 10660 \\ 10368 \\ \hline \end{array}$$

$$\begin{array}{r} 292 \\ \hline \end{array}$$

Contents = 244528 cubic inches.
Cu. in. of water weighs .036

$$\begin{array}{r} 1467168 \\ 733,584 \\ \hline \end{array}$$

$$\begin{array}{r} 2000) 8803008 (4 \text{ tons.} \\ 8000 \\ \hline \end{array}$$

803.008 pounds.
Answer = 4 tons + 803.008 pounds.

4. What is the pressure on the bottom of the tank when filled with water, depth being 2 feet 5 inches (82 cms)?

METRIC SYSTEM.

BRITISH SYSTEM.

No computation.
Answer = 82 grams per sq. cm.

Multiply number of inches in depth by weight of cubic inch of water—
2 ft. 5 in. = 29 inches.
1 cu. in. of water = .036 lbs.

$$\begin{array}{r} 174 \\ 87 \\ \hline \end{array}$$

Answer = 1.044 lbs. per sq. in.

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5. If the tank described above weighs 1700 pounds (771.12 kilogrammes) what volume of water will it displace if it be floated on a lake or river?

METRIC SYSTEM.

No computation.

Answer = 771.12 cubic decimetres.

BRITISH SYSTEM.

Multiply weight of tank by the number of cubic inches occupied by 1 pound of water—

62.5 lbs. of water occupy 1 cu. ft.
 62.5) 1700 (27.2 cu. ft.
 1250

4500

4375

1250

Answer 27.2 cubic feet.

8. It is also claimed by the advocates of the metric system that it would be an advantage to British and to Canadian manufacturers also to adopt this system, because if they are making goods for home consumption and also for export to countries using the metric system as well as to British and American markets it is necessary for them in many cases to have two sets of patterns or dies, whereas if the metric system were adopted in the British Empire and also in the United States, one set would suffice. It is also of importance to note in this connection that manufacturers are always making improvements and alterations in their articles or manufacture which necessitate the continual preparation of new patterns, models and designs, and it is just as easy to adopt the new system in new patterns as to continue the use of the older system.

9. The supporters of the metric system also claim that its adoption by the British Empire, including its dependencies, would greatly assist in preserving our foreign trade, and also constitute a most valuable means of extending it. Our consuls have frequently reported that we lose trade in consequence of our weights and measures not being understood in other countries. At the present time forty-three of the countries of the world have adopted the metric system as their sole official and legal system of weights and measures. Among these are the republics of South America, Egypt and Mauritius in Africa, Japan, Java and twenty-eight ports in China in Asia, and all the countries of Europe with the exception of Great Britain and Denmark. The metric system has been legalized in Great Britain and Ireland, and in most of the British dependencies, as well as in the United States, but it has not yet been exclusively adopted by these countries.

It is highly probable that the time is not distant when the whole of Africa will be opened up to commerce. Stable governments will be established there, and these will almost certainly adopt the metric system. The same process will go on in China and in other portions of Asia. The commercial interests of the British Empire and of the United States are sure to be affected by the development, and the maintenance of the present system of weights and measures by these nations will more and more be found to be a serious drawback to the extension of their foreign trade.

1. The metric system has been adopted by the following forty-three countries :—

Europe.

Austria-Hungary and Territories,
 Belgium,
 Finland,
 France,
 French Colonies,
 Germany,
 Greece,
 Holland,
 Italy,

Norway and Sweden,
 Roumania,
 Russia,
 Servia,
 Spain,
 Switzerland,
 Bulgaria,
 Portugal, Azores and Maderia,
 Ottoman Empire.

APPENDIX No. 2

America.

Argentina,
Bolivia,
Brazil,
Central America,
Chili,
Colombia,
Costa Rica,
Cuba,
Ecuador,
Guatamela,

Hayti,
Honduras,
Mexico,
Nicaragua,
Peru,
Porto Rico,
Philippines,
Salvador,
Santo Domingo,
Uruguay.

Africa.

Egypt,

Mauritius.

Asia.

China (28 ports),
Java.

Japan,

2. The metric system has been legalized in Great Britain and Ireland* and in most of the British dependencies, including Canada.

3. The metric system has not been legalized in the following countries : Denmark, Morocco, Persia, Siam, interior of China, and Central Africa.

For these reasons, Mr. Chairman and gentlemen of the House of Commons, I do not hesitate to solicit your best endeavours towards the adoption by the Dominion of Canada of a system which I venture to think has so many practical advantages and which will advance the interests of the commercial and industrial none the less than the scientific pursuits of the country.

*At the Coronation Conference of the Colonial Premiers, held in London, in 1902, the following resolution was adopted :—

'That it is advisable to adopt the metric system of weights and measures for use within the Empire, and the Prime Ministers urge the Governments represented at this Conference to give consideration to the question of its early adoption.'

On the 23rd of February, 1904, a Bill for rendering compulsory on and after the 5th day of April, 1906, or such later date as His Majesty may by Order in Council fix, the use of the system of weights and measures commonly known as the metric system, received its second reading in the British House of Lords and was referred to a Select Committee.

ERRATA.

Page 15, line 41, "1887" should read "1837."

Page 17, line 14, "metre units" should read "metric units."

Page 20, line 8, "Ling" should read "Link."

Page 22, footnote on "The Standard Pound," "five hundred" should read "five thousand."

Page 23, paragraph "7," line 7, "or" should read "and."